U.S. Department of Transportation
National Highway Traffic Safety Administration

Electronic Stability Control Confirmation Test

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Office of Vehicle Safety
Office of Crash Avoidance Standards
Room W43-478, NVS-120
1200 New Jersey Avenue , SE
WASHINGTON, DC 20590

ELECTRONIC STABILITY CONTROL
CONFIRMATION TEST

TABLE OF CONTENTS

1. PURPOSE AND APPLICATION

This laboratory test procedure provides the specifications for conducting confirmation tests of the existence of an Electronic Stability Control (ESC) system on passenger vehicles under 10,000 pounds gross vehicle weight rating (GVWR). This test procedure is not intended to be substituted for compliance with Federal Motor Vehicle Safety Standard 126, “Electronic Stability Control Systems”. Rather this procedure measures adequate characteristics exist for the system to accurately be called an ESC system.

The contract laboratories are directed by this test procedure to use a special test parameter specified in this test procedure document. The requirements of this indicant test procedure must be strictly adhered to; however, the test contractors are encouraged to suggest improved testing techniques to assist in procuring the required crash test data. Any changes to or deviations from this test procedure must be approved by the Contracting Officer's Technical Representative (COTR).

The contractor's in-house test procedure must have NHTSA approval prior to conducting the first crash test of a particular fiscal year program. The contractor's test procedure cannot deviate in any way from the NHTSA procedure without the prior approval of the NHTSA COTR.

2. GENERAL REQUIREMENTS

For a vehicle to be clearly declared having an Electronic Stability Control (ESC) Systems in our consumer information system, vehicles must be equipped with an ESC system that is capable of applying brake torques individually to all four wheels and has a control algorithm that utilizes this capability, is operational during all phases of driving including acceleration, coasting, and deceleration (including braking), except when the driver has disabled ESC, the vehicle speed is below 15 km/h (9.3 mph), or the vehicle is being driven in reverse, and remains capable of activation even if the antilock brake system or traction control system is activated. Vehicles to which this standard applies must meet specific lateral stability and responsiveness performance requirements.

Yaw rate thresholds are used to assess a vehicle’s lateral stability. At 1.0 second after completion of a required sine with dwell steering input, the yaw rate of a vehicle must not exceed 35 percent of the first peak value of yaw rate recorded after the steering wheel angle changes sign (between first and second peaks during the same test run). At 1.75 seconds after completion of a required sine with dwell steering input, the yaw rate of the same vehicle must not exceed 20 percent of the first peak value of yaw rate recorded after the steering wheel angle changes sign (between first and second peaks during the same test run).

Lateral displacement is used to assess a vehicle’s responsiveness. The lateral displacement of the vehicle center of gravity with respect to its initial straight path must be at least 1.83 m (6 feet) for vehicles with a GVWR of 3,500kg (7,716 lb) or less, and 1.52 m (5 feet) for vehicles with a GVWR greater than 3,500 kg (7,716 lb) when computed at specified commanded steering wheel angles 1.07 seconds after the Beginning of Steer (BOS).

An ESC system must have the capability to identify and warn of system malfunctions.

3. SECURITY

The contractor shall provide appropriate security measures to protect test vehicles and equipment during the entire test program, and shall be responsible for all equipment removed from test vehicles before and after the crash test. Vehicle equipment thefts or act of vandalism must be reported to NHTSA authorities immediately. Under no circumstances shall any vehicle components be removed during a visitor inspection unless authorized by OCAS engineers. All data developed from the crash test program shall be protected.

NO INDIVIDUALS other than the contractor's personnel directly involved in the test program shall be allowed to witness a test, inspect, or photograph any test vehicle unless authorization is granted by a representative from the OCAS. It is the contractor's responsibility to secure the test site area during a test.

Rules for Contractors

1. No vehicle manufacturer's representative(s) or anyone other than the contractor's personnel working on the Contracts and NHTSA personnel, shall be allowed to inspect test vehicles or witness vehicle preparations and/or testing without prior permission of the Office of Crash Avoidance Standards (OCAS). Such permission can never be assumed.

2. All communications with vehicle manufacturers shall be referred to the OCAS, and at no time shall the contractor release test data without the permission of the OCAS.

3. Unless otherwise specified, the vehicle manufacturer's representatives shall only be authorized to visit the contractor's test facility on the day that the test is scheduled, and the representatives must be escorted by NHTSA and/or contractor personnel.

4. Test vehicle inspection by the vehicle manufacturer's representative(s) shall be limited to 30 minutes prior to the start of vehicle test. Post-test inspection shall be limited to 1 hour after contractor personnel have completed their test tasks.

5. Photographs and videos of the test vehicle, associated test equipment and test

event shall be allowed. However, test personnel shall not be included in any photographic coverage, and videotaping of vehicle preparation must be approved by OCAS. The contractor's personnel shall not respond to any questions from the manufacturer's representatives regarding this test program. All questions shall be referred to the COTR, an OCAS representative present at the test site, or to OCAS.

6. VISITATIONS - The contractor shall permit public access to and inspection of the test vehicles and related data during the times specified by the NHTSA COTR. NHTSA shall advise interested parties that such access and inspection shall be limited to a specified day, and specified hours and require prior approval from the Office of Crash Avoidance Standards. The contractor shall refer all visit requests from vehicle manufacturer's representatives and consumers to the Office of Crash Avoidance Standards. This service shall be included as an incidental part of the crash test program and will not result in any additional cost to the NHTSA. The contractor shall make his own arrangements with interested parties for expenses incurred beyond providing access and inspection services. All inquiries by manufacturers concerning the test program (vehicle, procedures, data, etc.) shall be directed to OCAS representatives.

4. GOOD HOUSEKEEPING

The contractor will maintain the entire test area, vehicle pre-test preparation facility, instrumentation building, and equipment configuration and performance verification test laboratory in a clean, organized and painted condition. All test instrumentation must be setup in an orderly manner consistent with good engineering practices.

5. TEST SCHEDULING AND MONITORING

The contractor shall commence testing within four (4) weeks after receipt of the first test vehicle. Subsequent tests will be conducted, if requested, at a minimum of one (1) vehicle test per week. The NHTSA COTR will make adjustments to the test schedule in cases of unusual circumstances such as inclement weather or difficulty experienced in the procurement of a particular vehicle make and model. All testing shall be coordinated to allow monitoring by the COTR.

6. TEST DATA DISPOSITION

The contractor shall make all test data available within two hours after the test event if so requested by Agency personnel. Under no circumstances shall this data be furnished to non-Agency personnel. The contractor shall analyze the preliminary test results as directed by the COTR.

6.1 Computer Data and Final Hard-Copy

The contractor shall deliver to OCAS the final data, digital printouts, and plots within one (1) week after the crash test.

6.2 Test Report

6.2.1 This test report shall include all of the items shown in the Sample Test Report. The contractor shall submit **two (2)** CD's and **one (1)** paper copy of the test report to the following address:

U. S. Department of Transportation
National Highway Traffic Safety Administration
Office of Crash Avoidance Standards (NVS-120)
1200 New Jersey Avenue, SE, Room W43-478
Washington, DC 20590

6.2.2 Report Submission

All final test reports shall be submitted to the above listed NHTSA office within **four (4) weeks** from the date of the vehicle crash test.

6.2.3 Text/Data Sheet CD

The contractor shall submit **one (1)** CD of the text and data sheet portion only of the test report in Microsoft Word format within **four (4)** weeks from the date of the vehicle crash test. The full test report including photographs and data traces on a CD may be a future requirement.

6.3 Test Video

OCAS shall receive **one (1)** copy of the color video for each test, and the copies shall be mailed directly to the OCAS within **four (4)** weeks of the vehicle crash test. The master print for each of the crash test videos shall be retained by the contractor, but will be made available to the OCAS upon request.

6.4 Data Loss

6.4.1 Conditions for RETEST

The test vehicle is instrumented in order to obtain data needed for the test program. The data from tests, specifically from those channels providing *Handwheel angle and yaw* are absolutely essential to test program. An invalid test is one which does not conform precisely to all requirements/specifications of the laboratory test procedure and Statement of Work applicable to the test.

The contracting officer of NHTSA is the only NHTSA official authorized to notify the contractor that a retest is required.

No test report is required for any test which is determined to be invalid unless NHTSA specifically decides to require the Contractor to submit such report. Invalidated test reports will not be publicly released.

RETEST CONDITIONS

Failure of the contractor to obtain the above data and to maintain acceptable limits of test parameters in the manner outlined in this test procedure shall require a retest at the expense of the contractor and will include the cost of the vehicle replacement and retest at the contractor's expense. The provisions of this paragraph apply to, but are not limited to, the contractor maintaining proper speed tolerance, and test data acquisition, reduction, and processing.

The contractor shall also be responsible for obtaining usable data from all primary channels from the steering controller, vehicle speed and vehicle dynamics package instrumentation. Failure to produce such data shall also be at the expense of the contractor and shall include vehicle replacement and retest unless the Office of Crash Avoidance Standards determines that the data loss occurred through conditions beyond reasonable and foreseeable control of the contractor. Should it become necessary for the contractor to procure another test vehicle, it must have identical equipment and options as the original vehicle. The retested vehicle shall be retained without fee by the testing facility until its disposal is authorized by the COTR.

6.4.2 Conditions for PARTIAL PAYMENT

The contractor shall exercise reasonable and foreseeable control to insure that no data is lost or rendered useless. If some non-critical data (such as camera failure) and critical data (acceleration data) are not obtained for the test and the test is accepted by the Agency, the Agency will not pay for the missing or lost data.

6.5 Data Retention by Contractor

The contractor shall retain at no extra cost to the agency, reproducible copies of all data tapes (analog and digital), videos, and still photograph negatives or electronic files.

6.6 Data Availability to the Public

The contractor shall provide interested parties with copies of test report, test CD's, test data tapes, test films, and test still photographs, at a reasonable cost to the purchaser, but only after the Office of Crash Avoidance Standards representative has advised the contractor that the results of that particular test have been released to the public by the Agency.

6.7 Indicant Failure Notification

Any indication of a "test failure" shall be communicated by telephone to COTR within 24 hours of the test.

NOTE: In the event of a failure, a post-test calibration check of some critically sensitive test equipment and instrumentation may be required for verification of accuracy. The necessity for the calibration shall be at the COTR's discretion and shall be performed without additional cost.

7. VEHICLES AND EQUIPMENT AQUISITION

7.1 ACCEPTANCE OF TEST VEHICLES

The Contractor has the responsibility of accepting Leased or NHTSA-provided test vehicles from either new car dealers or vehicle transporters. In both instances, the Contractor acts in the Agency's behalf when signing an acceptance of test vehicles. The Contractor must check to verify the following:

A. All options listed on the "window sticker" are present on the test vehicle.

B. Tires and wheel rims are the same as listed.

C. There are no dents or other interior or exterior flaws.

D. The vehicle has been properly prepared and is in running condition.

E. Verify that spare tire, jack, lug wrench, and tool kit (if applicable) is located in the vehicle cargo area.

The Contractor shall check for damage that may have occurred during transit or prior use. The COTR is to be notified of any damage prior to preparation of the vehicle for testing.

7.2 NOTIFICATION OF COTR

The COTR must be notified within 24 hours after a vehicle has been delivered.

7.3 GOVERNMENT FURNISHED EQUIPMENT (GFE)

For the Electronic Statility Control Confirmation test, there is no Government Furnished Equipment (GFE).

8. INSTRUMENTATION AND CALIBRATION

8.1 SUGGESTED TEST EQUIPMENT

A. Portable tire pressure gage with an operating pressure of at least 700kPa (100 psi), graduated increments of 1 kPa (0.1 psi) and an accuracy of at least $\pm$ 2.0% of the applied pressure.

B. Platform scales to measure individual wheel, axle and vehicle loads. Platform scales shall have a maximum graduation of 1 kg (0.5 lb) and have an accuracy of at least $\pm$ 1% of the measured reading.

C. Automated steering machine with steering angle encoder for controlling steering wheel angle input and output. Automated steering machine is used to generate steering inputs for all test maneuvers. The automated steering machine shall be capable of supplying steering torques between 40 to 60 Nm (29.5 to 44.3 lb-ft). The steering machine must be able to apply these torques when operating with steering wheel velocities up to 1200 deg/sec. The steering machine must be able to move the vehicle's steering system through its full range, accept vehicle speed sensor feedback input to initiate steering programs at a preset road speeds, and have the convenience of changing the steering program during test sessions. Handwheel angle resolution is 0.25 deg and accuracy is $\pm$ 0.25 deg (ATI Model Spirit 3 or equivalent).

D. Multi-Axis Inertial Sensing System for measuring longitudinal, lateral and vertical accelerations as well as roll, yaw and pitch rates. Accelerometer range $\pm$ 2g, resolution $\leq$ 10μg, and accuracy $\leq$ 0.05% of full range. Angular rate sensors range $\pm$ 100 deg/sec, resolution $\leq$ 0.004 deg/sec and accuracy 0.05% of full range (BEI Motion PAK or equivalent).

E. Radar speed sensor with dashboard display for vehicle speed with a range of 0-

125 mph, resolution .009 mph and accuracy ± .25% of full scale (DEUTA-WERKE Model DRS-6 or equivalent).

F. Two ultrasonic distance measuring system sensors, to determine vehicle displacements that will be used to calculate roll angle, with a range of 5-24 inches, resolution 0.01 inches and accuracy ± .25% of maximum distance (MASSA Model M-5000/220 or equivalent).

G. Data acquisition system to record time, velocity, roll height, lateral, longitudinal and vertical accelerations, roll, yaw and pitch rates, and steering wheel angles from vehicle installed sensors. All data is to be sampled at 200 Hz. Signal conditioning must consist of amplification, anti-alias filtering, and digitizing. Amplifier gains are selected to maximize the signal-to-noise ratio of the digitized data. Filtering is performed with two-pole low-pass Butterworth filters with nominal cutoff frequencies selected to prevent aliasing. (Dewetron Sidehand model DA-121-16 with A/D card Orion-1616-100, and amplification/anti-aliasing card MDAQ-FILT-10-S)

H. Load Cell to monitor brake pedal force with a range of 0-300 lb and accuracy ± .05% full scale (Interface Model BPL 300 or equivalent).

I. Outriggers must be used for testing trucks, multipurpose passenger vehicles, and buses. Vehicles with a baseline weight under 2,722 kg (6,000 lbs) must be equipped with “standard” outriggers and vehicles with a baseline weight equal to or greater than 2,722 kg (6,000 lbs) must be equipped with “heavy” outriggers. A vehicle’s baseline weight is the weight of the vehicle delivered from the dealer, fully fueled, with a 73 kg (160 lb) driver. Standard outriggers shall be designed with a maximum weight of 32 kg (70 lb) and a maximum roll moment of inertia of 35.9 kg-m² (26.5 ft-lb-sec²). Heavy outriggers shall be designed with a maximum weight of 39 kg (86 lb) and a maximum roll moment of inertia of 40.7 kg-m² (30.0 ft-lb-sec²) (NHTSA titanium outrigger system, Docket No. NHTSA 2007-7662-11, or equivalent).

J. Real time digital video camera for documenting sine with dwell maneuver (Sony Model DCR-TRV950 or equivalent).

8.2 Calibration

Before the Contractor initiates the test program, a test instrumentation calibration system must be implemented and maintained in accordance with established calibration practices. Guidelines for setting up and maintaining such calibration systems are described in MIL-C-45662A, “Calibration System Requirements.” The calibration system shall be set up and maintained as follows:

A. Standards for calibrating the measuring and test equipment will be stored and used under appropriate environmental conditions to assure their accuracy and stability.

B. All measuring instruments and standards shall be calibrated by the Contractor, or a commercial facility, against a higher order standard at periodic intervals not exceeding 6 months for instruments and 12 months for the calibration standards. Records, showing the calibration traceability to the National Institute of Standards and Technology (NIST), shall be maintained for all measuring and test equipment. The calibration frequency can be increased if deemed necessary by NHTSA.

1. FREQUENCY RESPONSE - The accelerometer sensitivity is monitored as the frequency is cycled from approximately 10 to 10000 HZ. The sensitivity should remain fixed.

2. LINEARITY - The accelerometer placed on a shaker table, is cycled from 5g to 100g at100HZ. There should be minimal sensitivity variation throughout the cycle as described in SAE J211. The sensitivity of the accelerometer should also be compared to previous calibration values, and to the manufacturer's initial submitted value. If a variation greater than approximately 2 to 5% (not specified) is recorded, than the accelerometer should not be used. In addition, the zero offset of the unit should be compared to previous values.

3. TRANSIENT WIDE BAND FREQUENCY DROP TEST - For this test, the accelerometer alongside a known standard and utilizing a drop tower, is dropped from varying heights. The accelerometer output is compared to the standard. In this setup, both frequency response and the amplitude linearity can be checked. The amplitude frequency response should beat a minimum up to CLASS 1000 as defined by SAE J211. The amplitude response of the accelerometer from the different drop heights can be used to compute the amplitude linearity tolerance. The drop heights are arbitrary, but it is recommended that the accelerometer be dropped from at least one height which produces a g level that is greater than that expected in the actual test environment.

4. SENSOR HISTORY - A sensor calibration history should be maintained. During each calibration, prior values should be referenced. If wide disparities exist between values, then the sensor should not be used.

C. All measuring and test equipment and measuring standards will be labeled with the following information:

(1) Date of calibration

(2) Date of next scheduled calibration

(3) Name of the technician who calibrated the equipment

D. A written calibration procedure shall be provided by the Contractor which includes as a minimum the following information for all measurement and test equipment:

(1) Type of equipment, manufacturer model number, etc.

(2) Measurement range

(3) Accuracy

(4) Calibration interval

(5) Type of standard used to calibrate the equipment (calibration traceability of the standard must be evident)

(6) The actual procedures and forms used to perform the calibrations.

E. Records of calibration for all test instrumentation shall be kept by the Contractor in a manner that assures the maintenance of established calibration schedules. All such records shall be readily available for inspection when requested by the COTR and shall be included in the final test report. The calibration system will need the acceptance of the COTR before testing commences.

F. Test equipment shall receive a pre- and post-test zero and calibration check. This check shall be recorded by the test technician(s) and submitted with the final report.

NOTE: In the event of a failure to meet the standard's minimum performance requirements additional calibration checks of some critically sensitive test equipment and instrumentation may be required for verification of accuracy. The necessity for the calibration will be at the COTR's discretion and will be performed without additional cost.

8.3 TEST FACILITY DATA

A. Document the test track peak friction coefficient (PFC). The road test surface must produce a PFC of at least 0.9 when measured using an American Society for Testing and Materials (ASTM) E1136 standard reference test tire, in accordance with ASTM Method E 1337-90, at a speed of 64.4 km/h (40 mph), without water delivery.

B. Verify that the test track being used is dry and uniform with a solid-paved surface. Surfaces with irregularities and undulations, such as dips and large cracks, are unsuitable. The test surface must have a consistent slope between level and 1%.

C. Inflate vehicle tires to the recommended cold inflation pressure as specified on the vehicle placard or optional tire inflation pressure label.

D. Fill the fuel tank and other reservoirs of fluids necessary for operation of the vehicle prior to executing this test.

E. Measure vehicle’s wheelbase and front track width.

9. PHOTOGRAPHIC DOCUMENTATION

Each test shall be documented on a color video camera. Sun or light glare must be minimized so that views of the test are visible for visual analysis.

9.1 CAMERAS REQUIRED

CAMERA 1
Real-time video behind the test vehicle.

CAMERA 2
Real-time video camera to one side of the most significant even area of the test.

CAMERA 3
A still camera to document the vehicle.

9.2 INFORMATIONAL PLACARDS

Vehicle identification placards shall be positioned so that at least 1 placard will be visible in the field-of-view for at least one video camera The following information will be shown:

A. Vehicle's NHTSA Number

B. The words “ELECTRONIC STABILITY CONTROL CONFIRMATION TEST”

C. Date of test

D. Name of contract laboratory

E. Vehicle year, make and model

9.3 TEST FILM TITLE AND ENDING

Test video shall include the following title frames:

A. “The following Electronic Stability Control test was conducted under contractwith the National Highway Traffic Safety Administration by (name and location of test laboratory)”

B. ELECTRONIC STABILITY CONTROL TEST

TEST VEHICLE MODEL YEAR, MAKE AND MODEL

NHTSA No. CXXXXX

DATE OF IMPACT EVENT

CONTRACT NO.: DTNH22-9X-X-XXXXX

C. The ending frame shall state “THE END”

9.4 FILM EDITING

The film shall be edited in the following sequence:

A. Title

B. Pretest Coverage

C. Real Time Pan Coverage

D. Post test Coverage

E. “The End”

Any vehicle failures shall be completely documented.

9.11 STILL PHOTOGRAPHS

Provide still photographs (8 x 10 or $8^1/_2$ x 11 inch color prints properly focused for clear images) of pretest and post-test condition of entire vehicle deformation and details that pertain to the tested standards. Photographs of all areas of the test vehicle that may be of importance to the frontal barrier impact test should be taken in excess and developed only if the need arises.

The following still photographs are required for the test:

A. Pretest left side view of test vehicle

B. Pretest right front three-quarter view of test vehicle

C. Photograph of ballast installed in vehicle

D. Photograph of certification label

E Photograph of tire placard

F Photograph of the impact

10. DEFINITIONS

ACKERMAN STEER ANGLE

The angle whose tangent is the wheelbase divided by the radius of the turn at a very low speed.

Electronic Stability Control System or ESC System means a system that has all of the following attributes:

(1) That augments vehicle directional stability by applying and adjusting the vehicle brake torques individually to induce a correcting yaw moment to a vehicle;

(2) That is computer controlled with the computer using a closed-loop algorithm to limit vehicle oversteer and to limit vehicle understeer;

(3) That has a means to determine the vehicle's yaw rate and to estimate its side slip or side slip derivative with respect to time;

(4) That has a means to monitor driver steering inputs;

(5) That has an algorithm to determine the need, and a means to modify engine torque, as necessary, to assist the driver in maintaining control of the vehicle, and

(6) That is operational over the full speed range of the vehicle (except at vehicle speeds less than 15 km/h (9.3 mph) or when being driven in reverse).

ELECTRONIC STABILITY CONTROL SYSTEM

A system that has all the following attributes: (1) That augments vehicle directional stability by applying and adjusting the vehicle brake torques individually to induce a correcting yaw moment to a vehicle; (2) That is computer controlled with the computer using a closed-loop algorithm to limit vehicle oversteer and to limit vehicle understeer; (3) That has a means to determine the vehicle's yaw rate and to estimate its side slip or side slip derivative with respect to time; (4) That has a means to monitor driver steering inputs; (5) That has an algorithm to determine the need, and a means to modify engine torque, as necessary, to assist the driver in maintaining control of the vehicle, and (6) That is operational over the full speed range of the vehicle (except at vehicle speeds less than 15 km/h (9.3 mph) or when being driven in reverse).

LATERAL ACCELERATION

The component of the vector acceleration of a point in the vehicle perpendicular to the vehicle x axis (longitudinal) and parallel to the road plane.

OVERSTEER
A condition in which the vehicle's yaw rate is greater than the yaw rate that would occur at the vehicle's speed as result of the Ackerman Steer Angle.

SIDESLIP OR SIDE SLIP ANGLE
The arctangent of the lateral velocity of the center of gravity of the vehicle divided by the longitudinal velocity of the center of gravity.

UNDERSTEER
A condition in which the vehicle's yaw rate is less than the yaw rate that would occur at the vehicle's speed as a result of the Ackerman Steer Angle.

UVW
The Unloaded Vehicle Weight (UVW) is the weight of a vehicle with maximum capacity of all fluids necessary for vehicle operation, but without cargo, occupants, or accessories that are ordinarily removed from the vehicle when they are not in use.

VEHICLE PLACARD AND OPTIONAL TIRE INFLATION PRESSURE LABEL
The sources of cold tire inflation pressure recommended by the vehicle manufacturer and provided in the location and format per Federal motor vehicle safety standard (FMVSS) No. 110.

YAW RATE
The rate of change of the vehicle's heading angle measured in degree/second of rotation about a vertical axis through the vehicle's center of gravity.

11. PRETEST AND FACILITY REQUIREMENTS

11.1 VEHICLE PREPARATION

All non-fuel fluids must be at full capacity. Fuel must be maintained between 75 percent and 100 percent capacity. Inflate vehicle tires to the recommended cold inflation pressure as specified on the vehicle placard or optional tire inflation pressure label. Measure vehicle's wheelbase and front track width.

A. Inflate vehicle tires to the recommended cold inflation pressure as specified on the vehicle placard or optional tire inflation pressure label.

B. Fill the fuel tank and other reservoirs of fluids necessary for operation of the vehicle prior to executing this test.

C. Measure vehicle's wheelbase and front track width.

D. Weigh unloaded vehicle. Document unloaded vehicle weight (UVW).

E. For vehicles other than passenger cars, install outriggers on vehicle. To determine outrigger size required for test vehicle, add weight of test driver (73 kg (160lb)) to the UVW determined in F to calculate vehicle baseline weight. The vehicle baseline weight should be used to determine the size of outriggers to use as discussed in paragraph 9.I. With outriggers installed, again determine and document vehicle weight.

F. On vehicles equipped with outriggers install suitable inner tubes and return tire/wheel assemblies in original positions on the test vehicle. Use OEM torque on lugs.

G. Remove steering wheel air bag and vehicle center console.

H. Manufacture and install inertial sensing system mounting plate. (Mounting plate should be installed as close as possible to the perceived vehicle CG.)

I. Install Data Acquisition system (DAS) into front passenger seat.

J. Install inertial sensing system.

K. Install brake pedal force load cell.

L. Install vehicle speed sensor onto front outrigger or bumper assembly along vehicle centerline. Install vehicle speed dashboard display.

M. Install automatic steering controller. Insure controller is centered onto vehicle steering wheel.

N. Power up DAS and verify all channels are activated by viewing real time signal input data and observing normal data drift. Verify DAS displays accurate calibrated sensor outputs.

O. Verify calibration of steering controller encoder by confirming 1 full rotation of the steering controller wheel results in a reading of 360 degrees on the DAS.

P. Verify the steering controller triggers a steering maneuver at the correct vehicle speed by injecting a voltage into the speed sensor connection to simulate speed.

Q. Weigh vehicle with test equipment and test driver. Calculate the required ballast so the total interior load is 168 kg(370 lb) comprising the test driver, test equipment and ballast as required to account for the differences in the weight of test drivers and test equipment.

R. Place calculated amount of ballast on the floor behind the passenger front seat or if necessary in the front passenger foot well area. Weigh the vehicle and verify a total vehicle interior load of 168 kg (370 lb). Secure ballast in a way that prevents it from becoming dislodged during test conduct. Document loaded vehicle weight.

S. Using a Faro-Arm, measure the coordinates of the inertial sensing system and the vehicle's maximum roof height.

T. Determine the loaded vehicle's longitudinal and lateral center of gravity (CG) coordinates. The vertical CG coordinate is estimated to be 38% of the vehicle's maximum roof height. Document CG coordinates for the vehicle's loaded configuration.

U. Readjust location of ultrasonic distance measuring sensors to align with the vehicle's measured longitudinal center of gravity position.

11.2 BRAKE CONDITIONING

A. Verify tires are properly inflated to the vehicle manufacturer's recommended cold inflation pressures.

B. Measure and record ambient temperature and wind speed. Verify wind speed and ambient temperature are within required test conditions.

C. Energize the data acquisition system. Set data acquisition system so vehicle longitudinal acceleration can be observed on the system's display by the test driver.

D. Execute ten stops from a speed of 56 km/h (35 mph), with an average deceleration of approximately 0.5g. During each brake application the test driver will visually monitor the actual measured longitudinal acceleration on the data acquisition system display and attempt to maintain the target of 0.5g deceleration over the entire brake event.

E. Immediately following the series of 56 km/h (35 mph) stops, execute 3 stops from a speed of 72 km/h (45 mph). During the 72 km/h (45 mph) stops, brake pedal force should be great enough to activate the vehicle's antilock brake system (ABS) for the majority of each braking event. During each stop the test driver should be able to identify activation of the ABS (by feel or sound). If during a brake application the ABS does not activate the brake application should be repeated with increased brake pedal force. If the driver experiences any wheel lock-up he/she should confer with the COTR before proceeding.

F. Following completion of the final 72 km/h (45 mph) stop, the vehicle shall be driven at a speed of 72 km/h (45 mph) for at least five minutes to cool the brakes.

11.3 TIRE CONDITIONING

Tire conditioning is required to wear away mold sheen and achieve tire operating temperatures immediately before executing the test maneuvers of 12.2.

A. Verify tires are properly inflated to the vehicle manufacturer's recommended cold inflation pressures.

B. Measure and record ambient temperature and wind speed. Verify wind speed and ambient temperature are within required test conditions.

C. Energize the data acquisition system. Set data acquisition system so vehicle measured lateral acceleration can be observed on the system's display by the test driver.

D. Drive the vehicle around a 30 meter (100 feet) diameter circle at a speed that produces a lateral acceleration of approximately 0.5 to 0.6 g for three clockwise laps followed by three counterclockwise laps. During each lap the test driver will visually monitor the actual measured lateral acceleration on the data acquisition system display and attempt to maintain the target of 0.5 to 0.6 g lateral acceleration over the entire 30 meter (100 feet) diameter circle. Make note of the targeted vehicle speed.

E. Energize the automatic steering controller. Program the controller with a 1Hz, 3 cycle sinusoidal steering pattern and a steering wheel angle that corresponds to a peak lateral acceleration of 0.5-0.6 g at a constant vehicle speed of 56 km/h (35 mph). To determine the appropriate steering wheel angle required several preliminary steering maneuvers must be conducted. Using a target steering wheel angle of 30 degrees execute the sinusoidal steering maneuver at 56 km/h (35 mph) while observing the lateral acceleration. Adjust the target steering wheel angle as necessary and repeat the steering maneuver until a peak lateral acceleration of 0.5-0.6 g is obtained at the programmed steering wheel angle. Document the steering wheel angle required that corresponds to a peak lateral acceleration of 0.5-0.6 g.

F. Program the steering controller with a 1HZ, 10 cycle sinusoidal steering pattern using the steering wheel angle for a peak lateral acceleration of 0.5-0.6 g determined in step E. Execute three steering maneuvers while maintaining a vehicle speed of 56 km/h (35 mph).

G. Modify the programmed steering controller 1HZ, 10 cycle sinusoidal steering pattern. The steering wheel angle for the first nine cycles should be the same as used in step F. The steering wheel angle for the tenth cycle should be twice that of the other cycles. Execute one steering maneuver while maintaining a vehicle speed of 56 km/h (35 mph).

NOTE: The maximum time permitted between all laps and passes executed in section 13.7 is five minutes.

11.4 TEST CONDITIONS

The Contractor must verify that the ambient temperature at the beginning of the test is in the specified temperature range (0°C (32°F) - 40°C (104°F)). The wind must not exceed 10 meters per second (22 mph).

11.5 ADDITIONAL PRE – TEST INSTRUCTIONS

The hood, hood latches, and any other hood retention components are engaged. Contractor add-on items, such as instrumentation, cameras, lights, etc., shall not interfere with vehicle operation, restraint system/air bag operation, photography, or operator safety. Items with sharp edges should be avoided.

11.6 DETAILED TEST AND QUALITY CONTROL PROCEDURES REQUIRED

Prior to conducting any test, Contractors are required to submit a detailed in-house test procedure to the COTR which includes:

A. A step-by-step description of the methodology to be used.

B. A written Quality Control (QC) Procedure which shall include calibrations, the data review process, report review, and the people assigned to perform QC on each task.

C. A complete listing of test equipment which shall include instrument accuracy and calibration dates.

D. Detailed checkoff lists to be used during the test and during data review. These lists shall include all test procedure requirements. Each separate checkoff sheet shall identify the lab, test date, vehicle and test technicians. These check sheets shall be used to document that all requirements and procedures have been complied with for each test. The check sheets should be kept on file.

There shall be no contradiction between the laboratory test procedure and the Contractor's in-house test procedure. The procedures shall cover all aspects of testing from vehicle receipt to submission of the final report. Written approval of the procedures must be obtained from the COTR before initiating the test program so that all parties are in agreement.

NOTE: Parts of the following may not apply to on-board data acquisition systems.

Prior to the vehicle test, a null reference and a shunt calibration adjustment are performed to set all analog and direct digitized data devices. Immediately following the test, a post impact null reference and shunt calibration check will be performed. The pre and post-test zero and shunt calibration check will be recorded and the data submitted with the report.

12. Test Execution and Test Requirements

12.1 EQIUPMENT REQUIREMENTS

Using information provide by the COTR from the vehicle manufacturer, the owners manuals, and shop manuals (if necessary) verify that the vehicle is equipped with an ESC system that meets the definition of ESC SYSTEM by providing the following:

Required Equipment. Vehicles to which this definition applies must be equipped with an electronic stability control system that:

12.1.1 Is capable of applying brake torques individually to all four wheels and has a control algorithm that utilizes this capability.

12.1.2 Is operational during all phases of driving including acceleration, coasting, and deceleration (including braking), except when the driver has disabled ESC, the vehicle speed is below 15 km/h (9.3 mph), or the vehicle is being driven in reverse.

12.1.3 Remains capable of activation even if the antilock brake system or traction control system is also activated.

12.2 Performance Requirements.

12.2.1 SLOWLY INCREASING STEER (SIS) MANEUVER

The SIS maneuver is used to characterize the lateral dynamics of each vehicle. The maneuver is used to provide the data necessary for determining the steering wheel angle capable of producing a lateral acceleration of 0.3 g. This steering wheel angle is then used to determine the magnitude of steering required during the sine with dwell maneuver executed in section 13.9.

A. The SIS maneuver should be executed immediately following the tire conditioning of section 13.7.

B. Verify tires are properly inflated to at least the vehicle manufacturer's recommended cold inflation pressures. If this activity follows any dynamic testing maneuvers, including brake conditioning and/or tire conditioning, expect the tire pressure to be somewhat above the recommended cold inflation pressures. In this case, do not decrease tire pressures.

C. Measure and record ambient temperature and wind speed. Verify wind speed and ambient temperature are within required test conditions.

D. Energize the data acquisition system and the automatic steering controller. Program the steering controller so at time zero the steering wheel angle is linearly increased from zero to 30 degrees at a rate of 13.5 degrees per second.

E. Position test vehicle on test course facing the direction SIS maneuvers will be executed. Collect fifteen seconds of data from all instrument channels with the test vehicle at rest, the engine running, the transmission in "Park" (automatic transmission) or neutral with the parking brake applied (manual transmission), and the front of the test vehicle pointing in the direction testing will occur. The static data file will be used in post processing to establish datums for each instrument channel.

F. Execute a preliminary left steer maneuver and measure the lateral acceleration at the 30 degree steering wheel angle. To begin, the vehicle is driven in a straight line at 80 ± 2 km/h (50 ± 1 mph). While maintaining a vehicle speed of 80 ± 2 km/h (50 ± 1 mph) using smooth throttle modulation, the driver should activate the steering controller. The driver must attempt to maintain a vehicle speed of 80 ± 2 km/h (50 ± 1 mph) during and briefly after the steering maneuver is executed by the steering controller. The 30 degree steering wheel angle must be held constant for two seconds after which the maneuver is concluded. The steering wheel is then returned to zero degrees. Document the measured lateral acceleration at the 30 degree steering wheel angle.

G. Assuming a linear relationship exists between the steering wheel angle and lateral acceleration, calculate the steering angle required to achieve a 0.55 g lateral acceleration using equation 1. See note below.

Equation 1:

$$\frac{30\,\text{degrees}}{a_{\text{y,30degrees}}} = \frac{\delta_{SIS}}{0.55\,\text{g}}$$

where,

$a_{y,30\ degrees}$ is the raw lateral acceleration produced with a constant SWA of 30 degrees during a test performed at 50 mph

$*_{SIS}$ is the steering wheel angle, if the relationship of SWA and lateral acceleration was linear, would produce a lateral acceleration of 0.55 g during a test performed at 50 mph

NOTE: The 30 degree steering wheel angle was selected by NHTSA because it is believed to be capable of producing a steady state lateral acceleration within the linear range for any light vehicle. The measured lateral acceleration ($a_{y,30\ degrees}$) is “raw” data, not corrected for the effects of roll, pitch, and yaw. NHTSA acknowledges the relationship of the steering wheel angle and *corrected* lateral acceleration data is often not linear at 0.55 g. However, previously collected data indicates the magnitude of raw 0.55 g acceleration data is typically reduced by approximately 9.6 percent to 0.50 g, when corrected for roll, pitch, and yaw, just outside of the linear range for most vehicles. Removing the effect of accelerometer offset (error due to the accelerometer not being positioned at the vehicle’s actual center of gravity) typically reduces the magnitude of these data by an additional 0.07 percent. The importance of the above equation is that it simply provides test laboratories with a direct, “in-the-field” way of determining an appropriate steering input for which to proceed with SIS test for a given vehicle.

H. Re-program the steering controller so at time zero the steering wheel angle is linearly increased from zero degrees to $*_{SIS}$ at a rate of 13.5 degrees per second, rounded to the nearest 10 degrees.

I. Execute an SIS maneuver to the left using the techniques in step F. and record the steering wheel angle and lateral acceleration data. If the lateral acceleration is below 0.50g, then increase the steering angle by 10 degrees. If the lateral acceleration is above 0.60g, then decrease the steering angle by 10 degrees.

J. Repeat step I. until three SIS maneuvers to the left have been completed where the lateral acceleration falls within 0.50g to 0.60g, the vehicle speed was 80± 2 km/h (50 ± 1 mph), and the maximum steering angle was held constant for two seconds after which the maneuver was concluded. The maximum time permitted between each test run maneuver is five minutes. Figure 1 presents a description of the SIS steering profile. For each of the three test runs document the time, steering wheel angle and lateral acceleration.

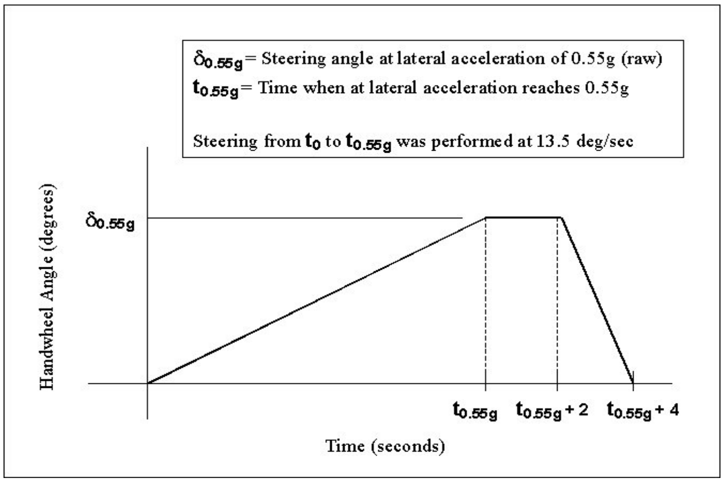

Figure 1. Slowly Increasing Steer steering profile.

K. Repeat step H. through J. until three SIS maneuvers to the right have been completed where the lateral acceleration falls within 0.50g to 0.60g, the vehicle speed was 80$\pm$ 2 km/h (50 $\pm$ 1 mph), and the maximum steering angle was held constant for two seconds after which the maneuver was concluded. The maximum time permitted between each test run maneuver is five minutes. For each of the three test runs document the time, steering wheel angle and lateral acceleration.

L. Obtain raw lateral acceleration data by filtering with a 12-pole phaseless Butterworth filter and a cutoff frequency of 6Hz. The filtered data is then zeroed to remove sensor offset utilizing static pretest data. The lateral acceleration data at the vehicle CG is determined by removing the effects caused by vehicle body roll and by correcting for sensor placement via use of coordinate transformation. For data collection, the lateral accelerometer shall be located as close as possible to the position of the vehicle's longitudinal and lateral CG.

M. Using linear regression techniques, determine the "best-fit" linear line for each of the six completed SIS maneuvers. When lateral acceleration data collected during SIS tests are plotted with respect to time, a first order polynomial (best-fit line) accurately describes the data from 0.1 to 0.375 g. NHTSA defines this as the linear range of the lateral acceleration response. A simple linear regression is used to determine the best-fit line, as shown in Figure 2.

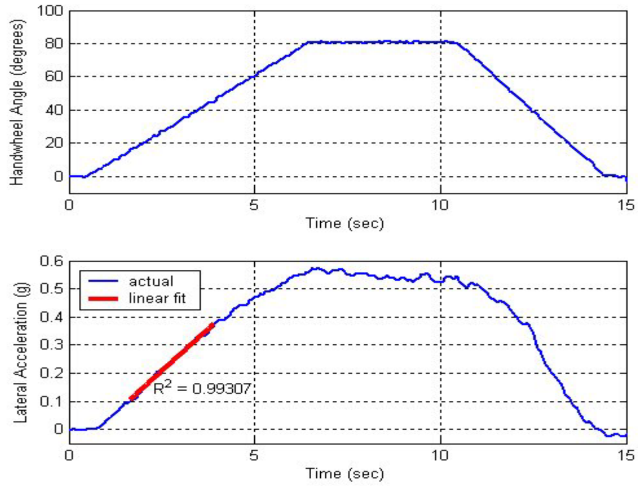

Figure 2. Sample steering wheel angle and lateral acceleration data recorded during a Slowly Increasing Steer test. The linear range used to define the lateral acceleration regression line is highlighted.

N. Using the slope of the best-fit line for each of the six SIS maneuvers, determine the steering wheel angle, to the nearest 0.1 degree, at 0.3 g for each respective maneuver. Using equation 2 calculate the average overall steering wheel angle, rounded to the nearest 0.1 degree, at 0.3 g using the absolute value data from each of the six SIS maneuvers.

Equation 2:

$$\delta_{0.3\text{ g, overall}} = \left(\left|\delta_{0.3\text{ g, left (1)}}\right| + \left|\delta_{0.3\text{ g, left (2)}}\right| + \left|\delta_{0.3\text{ g, left (3)}}\right| + \delta_{0.3\text{ g, right (1)}} + \delta_{0.3\text{ g, right (2)}} + \delta_{0.3\text{ g, right (3)}}\right) / 6$$

12.2.2 VEHICLE LATERAL STABILITY AND RESPONSIVENESS (SINE WITH DWELL MANEUVER) (Data Sheet 7)

The vehicle is subjected to two series of test runs using a steering pattern of a sine wave at 0.7 Hz frequency with a 500ms delay beginning at the second peak amplitude as shown in Figure 3 (the sine with dwell test). One series uses counterclockwise steering for the first half cycle, and the other series uses

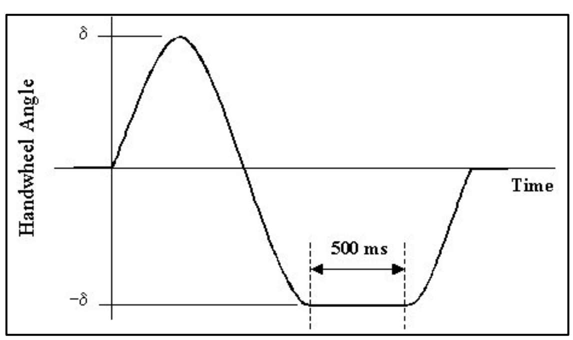

Figure 3. Sine with Dwell

clockwise steering for the first half cycle. The vehicle is provided a cool-down period between each test run of 90 seconds to five minutes, with the vehicle stationary. Ensure the sine with dwell test series begins within two hours after the completion of the SIS tests.

A. Repeat the tire conditioning procedure specified in section 13.7. Tire conditioning must be executed immediately prior to executing the sine with dwell maneuvers.

B. Verify that the ESC system is enabled, by ensuring that the ESC malfunction and "ESC OFF" (if provided) telltales are not illuminated.

C. Verify the data acquisition system is energized and conduct on-track calibration checks for speed, distance and inertial sensing system sensor output. At the completion of the tire conditioning procedure and before the start of a test series, fifteen seconds of data are collected from all instrument channels with the test vehicle at rest, the engine running, the transmission in "Park" (automatic transmission) or in neutral with the parking brake applied (manual transmission), and the front of the test vehicle facing in the direction the vehicle will be tested on the track. The static data files are used in post processing to establish datums for each instrument channel.

D. Energize the programmable steering controller. Program the controller to execute the sine with dwell maneuver using an initial counterclockwise steering direction. The first maneuver should be programmed with a steering wheel angle magnitude equal to 1.5 times $\delta_{0.3\text{ g, overall.}}$ as determined in section 13.7.

E. Depress the steering controller's program switch and then accelerate the vehicle to 87 $\pm$ 2 km/h (54$\pm$1 mph). Release the throttle, and when vehicle speed reaches the target speed of 80 $\pm$ 2 km/h (50 $\pm$ 1 mph) the steering controller will execute the programmed sine with dwell maneuver.

F. During the maneuver, test personnel must observe for loss of pavement contact of tires, rim-to-pavement contact and tire debeading. Rim-to-pavement contact will be verified by visual observation and identified by marks left on the pavement. Debeading will be verified by visual observation and a corresponding loss of tire inflation pressure. Loss of pavement contact of tires will be verified by visual observation and documented by video camera. If any of these events are observed or if the test driver experiences a vehicle loss of control or spinout the test should be terminated and the test laboratory must consult with the COTR before proceeding.

G. Safety outrigger height adjustment may be required during a test series. If an outrigger skid pad contacts the road surface during a test run wherein there is no spinout or wheel lift, the outrigger at the effected end of the vehicle is raised 19 mm (0.75 in) and the test run is repeated. If both outriggers make contact with the test surface during at test run wherein there is no spinout or wheel lift, both outriggers are raised 19 mm (0.75 in) and the test run is repeated.

H. Using the data from step E. plot the steering wheel angle, vehicle speed, lateral acceleration and yaw rate. Confirm the maneuver entrance speed was within $\pm$ 3 km/h (1mph) of desired speed, the steering wheel angle maximums were accurate, and both lateral acceleration and yaw rate seem reasonable. If any of the above conditions are not met, stop test and correct problem. If all conditions are met, then continue the test series.

I. Provide a cool-down period between each test run of 90 seconds to 5 minutes, with the vehicle stationary.

J. Continue to execute the counterclockwise steering maneuvers, each time increasing the steering wheel angle magnitude by multiples of $0.5*\delta_{0.3\text{ g, overall}}$. Maneuver execution should continue until a steering wheel angle magnitude factor of $6.5*\delta_{0.3\text{ g, overall}}$ or 270 degrees is utilized, whichever is greater, provided the calculated magnitude of $6.5*\delta_{0.3\text{ g, overall}}$ is less than or equal to 300 degrees. If $6.5*\delta_{0.3\text{ g, overall}}$ is less than 270 degrees maneuver execution should continue by increasing the steering wheel angle magnitude by multiples of $0.5*\delta_{0.3\text{ g, overall}}$ without exceeding the 270 degree steering wheel angle. If any $0.5*\delta_{0.3\text{ g, overall}}$ increment, up to $6.5*\delta_{0.3\text{ g, overall}}$, is greater than 300 degrees, the steering amplitude of the final run shall be 300 degrees.

K. Repeat paragraphs D. through J. using an initial clockwise steering direction.

13. POST TEST REQUIREMENTS

NHTSA uses MATLAB program routines for post data processing. These routines are available on line at………… Yaw rate and lateral displacement measurements and calculations are processed utilizing the following techniques:

A. Filter raw steering wheel angle data with a 12-pole phaseless Butterworth filter and a cutoff frequency of 10 Hz. Zero the filtered data to remove sensor offset utilizing static pretest data.

B. Filter raw yaw, pitch and roll rate data with a 12-pole phaseless Butterworth filter and a cutoff frequency of 6 Hz. Zero the filtered data to remove sensor offset utilizing static pretest data.

C. Filter raw lateral, longitudinal and vertical acceleration data with a 12-pole phaseless Butterworth filter and a cutoff frequency of 6 Hz. Zero the filtered data to remove sensor offset utilizing static pretest data.

D. Filter raw speed data with a 12-pole phaseless Butterworth filter and a cutoff frequency of 2 Hz.

E. Filter left side and right side ride height data with a 12-pole phaseless Butterworth filter and a cutoff frequency of 6 Hz. Zero the filtered data to remove sensor offset utilizing static pretest data.

F. Determine the roll, yaw and pitch accelerations by differentiating the filtered and zeroed roll and yaw rate data.

G. Determine the lateral acceleration at the vehicle center of gravity by correcting for sensor placement via use of coordinate transformation. The multi-axis inertial sensing system is used to measure linear accelerations and roll, pitch, and yaw angular rates. The position of the multi-axis inertial sensing system must be accurately measured relative to the C.G. of the vehicle in its loaded configuration. These data are required to translate the motion of the vehicle at the measured location to that which occurred at the actual C.G to remove roll, pitch, and yaw effects. The following equations are used to correct the accelerometer data in post-processing. They were derived from equations of general relative acceleration for a translating reference frame and use the SAE Convention for Vehicle Dynamics Coordinate Systems. The coordinate transformations are:

Equation 4: $x''_{corrected} = x''_{accel} - (\Theta'^{2} + \Psi'^{2})x_{disp} + (\Theta'\Phi' - \Psi'')y_{disp} + (\Psi'\Phi' + \Theta'')z_{disp}$

Equation 5: $y''_{corrected} = y''_{accel} + (\Theta'\Phi' + \Psi'')x_{disp} - (\Phi'^{2} + \Psi'^{2})y_{disp} + (\Psi'\Theta' - \Phi'')z_{disp}$

Equation 6: $z''_{corrected} = z''_{accel} + (\Psi'\Phi' - \Theta'')x_{disp} + (\Psi'\Theta' + \Phi'')y_{disp} - (\Phi'^{2} + \Theta'^{2})z_{disp}$

Where;

$x''_{corrected}$, $y''_{corrected}$, and $z''_{corrected}$ = longitudinal, lateral, and vertical accelerations, respectively, at the vehicle's center of gravity

x''_{accel}, y''_{accel}, and z''_{accel} = longitudinal, lateral, and vertical accelerations, respectively, at the accelerometer location

x_{disp}, y_{disp}, and z_{disp} = longitudinal, lateral, and vertical displacements, respectively, of the center of gravity with respect to the accelerometer location

Φ' and Φ'' = roll rate and roll acceleration, respectively

Θ' and Θ'' = pitch rate and pitch acceleration, respectively

Ψ' and Ψ'' = yaw rate and yaw acceleration, respectively

H. Correct lateral acceleration at the vehicle center of gravity by removing the effects caused by vehicle body roll. NHTSA does not use inertially stabilized accelerometers for this test procedure. Therefore, lateral acceleration must be corrected for vehicle roll angle during data post processing. The ultrasonic distance measurement sensors are used to collect left and right side vertical displacements for the purpose of calculating vehicle roll angle. One ultrasonic ranging module is mounted on each side of a vehicle, and is positioned at the longitudinal center of gravity. With these data, roll angle is calculated during post-processing using trigonometry.

Equation 7:

$$a_{yc} = a_{ym}\cos\Phi - a_{zm}\sin\Phi$$

Where;

a_{yc} is the corrected lateral acceleration (i.e., the vehicle's lateral acceleration in a plane horizontal to the test surface)

a_{ym} is the measured lateral acceleration in the vehicle reference frame

a_{zm} is the measured vertical acceleration in the vehicle reference frame

Φ is the vehicle's roll angle

Note: **The z-axis sign convention is positive in the downward direction for both the vehicle and test surface reference frames.**

I. Determine steering wheel velocity by differentiating the filtered and corrected steering wheel angle data. Filter the steering wheel velocity data using a moving 0.1 second running average filter.

J. Zero lateral acceleration, yaw rate and steering wheel angle data channels utilizing a defined “zeroing range.” The methods used to establish the zeroing range are as follows:

1. Using the steering wheel velocity data calculated using the methods described in I., the first instant steering wheel rate exceeds 75 deg/sec is identified. From this point, steering wheel rate must remain greater than 75 deg/sec for at least 200 ms. If the second condition is not met, the next instant steering wheel rate exceeds 75 deg/sec is identified and the 200 ms validity check applied. This iterative process continues until both conditions are ultimately satisfied.

2. The “zeroing range” is identified as the 1.0 seconds time period prior to the instant the steering wheel rate exceeds 75 deg/sec (i.e., the instant the steering wheel velocity exceeds 75 deg/sec defines the end of the “zeroing range”).

K. Determine the “Beginning of Steer” (BOS) which is defined as the first instance filtered and zeroed steering wheel angle data reaches -5 degrees (when the initial steering input is counterclockwise) or +5 degrees (when the initial steering input is clockwise) after time defining the end of the “zeroing range.” The value for time at the BOS is interpolated.

L. Determine the “Completion of Steer” (COS) which is defined as the time the steering wheel angle returns to zero at the completion of the sine with dwell steering maneuver. The value for time at the zero degree steering wheel angle is interpolated.

M. Determine the second peak yaw rate ($\dot{\psi}_{Peak}$) which is defined as the first local yaw rate peak produced by the reversal of the steering wheel. Refer to figure 4.

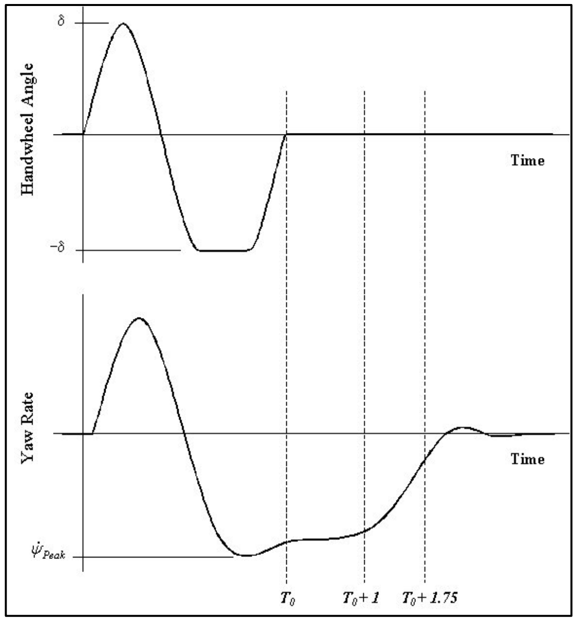

Figure 4. Steering wheel position and yaw velocity information used to assess lateral stability.

Note: In figure 4, $\dot{\psi}_{Peak}$ is the first local peak yaw rate resulting from the sine with dwell steering reversal. In some situations, the yaw rate produced by the steering reversal may reach a peak ($\dot{\psi}_{Peak}$), decay slightly, then increase to a level beyond a $\dot{\psi}_{Peak}$. Even though the overall peak magnitude of the yaw rate response may exceed $\dot{\psi}_{Peak}$, only $\dot{\psi}_{Peak}$ shall be used in the calculation process.

N. Determine the yaw rates at 1.000 and 1.750 seconds after COS are determined by interpolation for each counterclockwise and clockwise steering maneuvers.

O. For each of the steering maneuvers calculate the yaw rate ratio (YYR) at 1.00 second. The yaw rate measured one second after COS must not exceed 35 percent of the second peak value of the yaw velocity recorded ($\dot{\psi}_{Peak}$) during the same test run. The YYR is expressed as a percentage as shown in equation 3 below.

Equation 3:

$$\mathrm{YYR} = 100 * \left(\frac{\dot{\psi}(\text{at time } t)}{\dot{\psi}_{Peak}} \right)$$

P. Using equation 3 above, calculate yaw rate ratio (YYR) at 1.75 seconds for each of the steering maneuvers. The yaw rate measured 1.75 seconds after COS must not exceed 20 percent of the second peak value of the yaw velocity recorded ($\dot{\psi}_{Peak}$) during the same test run.

Q. For each of the steering maneuvers executed in sections 13.9 E., J., and K., with a steering wheel angle of $5^*\delta_{0.3\ g,\ overall}$ or greater, determine lateral velocity by integrating corrected, filtered and zeroed lateral acceleration data. Zero lateral velocity at BOS event.

R. Determine lateral displacement by integrating zeroed lateral velocity. Zero lateral displacement at BOS event.

S. Determine lateral displacement at 1.07 seconds from BOS event using interpolation. The lateral displacement of the vehicle center of gravity with respect to its initial straight path must be at least 1.83 (6 feet) for vehicles with a GVWR of 3,500 kg (7,716 lb) or less, and 1.52 m (5 feet) for vehicles with GVWR greater than 3,500 kg (7,716 lb) when computed 1.07 seconds after the BOS.

14. REPORTS

14.1 MONTHLY STATUS REPORTS

The Contractor shall submit a monthly Test Status Report and a Vehicle or Equipment Status Report to the COTR (both reports shown in this section). The Vehicle Status Report shall be submitted until all vehicles or items of equipment are disposed of.

14.2 TEST ANOMOLIES

In the event of an apparent test failure, a post-test calibration check of some critically sensitive test equipment and instrumentation may be required for verification of accuracy. The necessity for the calibration shall be at the COTR's discretion and shall be performed without additional costs to the OCAS.

14.3 FINAL TEST REPORT

14.3.1 COPIES

One(1) CD per test. Please add two items to the CD’s. Place a JPG of the vehicle being tested – 180 by 300 pixels and around 10 KB. For the second item, place a sample video of the vehicle being tested on the CD.

One paper copy of each Final Test Report.

The above documentation shall be submitted to the COTR according to the schedule indicated in section 6.

Payment of Contractor's invoices for completed tests may be withheld until the Final Test Report is accepted by the COTR. Contractors are requested to NOT submit invoices before the COTR is provided copies of the Final Test Report.

Contractors are required to submit one color copy of each Final Test Report in draft form. DO NOT stamp *preliminary* or *draft* on this report. The COTR will review the draft report and notify the laboratory of any corrections that are required. If we agree to make changes to the test report, mail the appropriate (the changed) pages to us. We will insert the new pages into the preliminary test report. At the end, we will accept the preliminary test report with the inserted pages as the final test report.

Contractors are required to PROOF READ all Final Test Reports before submittal to the COTR. The OCAS will not act as a report quality control office for Contractors. Reports containing a significant number of errors will be returned to the Contractor for correction, and a “hold” will be placed on invoice payment for the particular test.

14.3.2 REQUIREMENTS

The Final Test Report, associated documentation (including photographs) is relied upon as the chronicle of the test. The Final Test Report will be released to the public domain after review and acceptance by the COTR. For these reasons, each final report must be a complete document capable of standing by itself.

The Contractor should use detailed descriptions of all test events. Any events that are not directly associated with the test program but are of technical interest should also be included. The Contractor should include as much detail as possible in the report.

Instructions for the preparation of the first three pages of the final test report are provided below for the purpose of standardization.

14.3.3 FIRST THREE PAGES

Front Cover - - A heavy paperback cover (or transparency) shall be provided for the protection of the final report. The information required on the cover is as follows:

(A) Final Report Number such as OCAS-0X-001

where - -

OCAS is the test
ABC are the initials for the laboratory
0X is the Fiscal Year of the test program
001 is the Group Number (00 1 for the 1st test, 002 for the 2nd test, 003for the 3rd test, etc.)

(B) Final Report Title And Subtitle such as

ELECTONIC STABILITY CONTROL CONFIRMATION TEST
****
World Motors Corporation
200X XYZ 4-door sedan
NHTSA No. CX0401

(C) Contractor's Name and Address such as

XYZ TESTING LABORATORIES, INC.
4335 West Dearborn Street
Detroit, Michigan 48090

NOTE: NHTSA/DOT SYMBOL WILL BE PLACED BETWEEN ITEMS (C) AND (D)

(D) Date of Final Report completion

(E) The words "FINAL REPORT"

(F) The sponsoring agency's name and address as follows

U. S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Office of Crash Avoidance Standards
Mail Code: NVS-120
1200 New Jersey Avenue SE, Room W43-478
Washington, DC 20590

14. REPORTS.... Continued

First Page After Front Cover - - A disclaimer statement and an acceptance signature block for the COTR shall be provided as follows:

> This publication is distributed by the U.S. Department of Transportation, National Highway Traffic Safety Administration, in the interest of information exchange. The opinions, findings and conclusions expressed in this publication are those of the author(s) and not necessarily those of the Department of Transportation or the National Highway Traffic Safety Administration. The United States Government assumes no liability for its contents or use thereof. If trade or manufacturers' names or products are mentioned, it is only because they are considered essential to the object of the publication and should not be construed as an endorsement. The United States Government does not endorse products or manufacturers.

Prepared By: ______________________________________

Approved By: ______________________________________

Approval Date: ______________________________________

FINAL REPORT ACCEPTANCE BY OCAS:

____
Manager, NHTSA, Office of Crash Avoidance Standards

Date: ______________________________________

____
COTR, NHTSA, Office of Crash Avoidance Standards

Date: ______________________________________

14. REPORTS.... Continued

Second Page After Front Cover - - A completed Technical Report Documentation Page (Form DOT F1700.7) shall be completed for those items that are applicable with the other spaces left blank. Sample data for the applicable block numbers of the title page follows.

Block No. 1 - - REPORT NUMBER

OCAS-ABC-0X-001

Block No. 2 - - GOVERNMENT ACCESSION NUMBER

Leave blank

Block No. 3 - - RECIPIENT'S CATALOG NUMBER

Leave blank

Block No. 4 - - TITLE AND SUBTITLE

Final Report of OCAS Testing
of a 200X World XYZ Deluxe 4-door sedan
NHTSA No. CX0401

Block No. 5 - - REPORT DATE

March 1, 200X

Block No. 6 - - PERFORMING ORGANIZATION CODE

ABC

Block No. 7 - - AUTHOR(S)

John Smith, Project Manager
Bill Doe, Project Engineer

Block No. 8 - - PERFORMING ORGANIZATION REPORT NUMBER

ABC-DOT-XXX-001

Block No. 9 - - PERFORMING ORGANIZATION NAME AND ADDRESS

ABC Laboratories
405 Main Street
Detroit, MI 48070

14. REPORTS.... Continued

Block No. 10 - - WORK UNIT NUMBER

Leave blank

Block No. 11 - - CONTRACTOR GRANT NUMBER

DTNH22-0X-D-1 2345

Block No. 12 - - SPONSORING AGENCY NAME AND ADDRESS

U. S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Office of Crash Avoidance Standards
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1200 New Jersey Avenue SE, Room W43-478
Washington, DC 20590

Block No. 13 - - TYPE OF REPORT AND PERIOD COVERED

Final Test Report
XXX to XXX, 200X

Block No. 14 - - SPONSORING AGENCY CODE

NvS-120

Block No. 15 - - SUPPLEMENTARY NOTES

Leave blank

Block No. 16 - - ABSTRACT

These tests were conducted on the subject 200X World XYZ 4-door sedan in accordance with the specifications of the Office of Crash Avoidance Standards Test Procedure No. TP--XX for the confirmation of an Electronic Stability System.

Block No. 17 - - KEY WORDS

Electronic Stability Control test

14. REPORTS.... Continued

Block No. 18 - - DISTRIBUTION STATEMENT

Copies of this report are available from the following:

NHTSA Technical Reference Division
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Add appropriate number

Block No. 22 - - PRICE

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14.3.4 TABLE OF CONTENTS .... PAGE NO.

Sample Test Report Table of Contents:

A. Section 1 — Purpose and Summary of Test

B. Section 2 — Occupant and Vehicle Information/Data Sheets

C. Section 3 — Photographs

D. Section 4 — Vehicle data traces.

E. Section 5 — Test Equipment and Instrumentation Calibration

14. REPORTS.... Continued

14.3.5 SAMPLE TEST REPORT INFORMATION

PURPOSE AND SUMMARY OF TEST

PURPOSE

This test is part of the Electronic Stability Control Confirmation Test Program sponsored by the National Highway Traffic Safety Administration (NHTSA) under Contract No.___________. The purpose of this test was to obtain vehicle crash avoidance performance data to confirm the existence of a viable Electronic Stability Control system as specified in FMVSS 126.

SUMMARY

DATA SHEET NO. DESCRIPTION

1. Test Summary
2. General Test and Vehicle Parameter Data
3. Post test Data
4. Test Vehicle Information
5. Vehicle Measurements

15. DATA SHEETS

DATA SHEET NO. 1

TEST SUMMARY

Vehicle NHTSA No.: ____________________

Test Date: ______________________________ Time: _______________ Temperature: __________ °C

Vehicle Make/Model/Body Style: ____

Vehicle Test Weight: _____________________________ kg

Forward Crash Warning Confirmed ____________________

DATA SHEET NO. 2

GENERAL TEST AND VEHICLE PARAMETER DATA

TEST VEHICLE INFORMATION:

Year/Make/Model/Body Style: ____

NHTSA No.: _____________; VIN: ____________________________; Color: ___________

Engine Data: cylinders; ___________CID; _______Liters; __________cc

Transmission Data: ______speeds; _________Manual; __________Automatic; _________Overdrive

Final Drive: ___Rear Wheel Drive; ___Front Wheel Drive; ___________Four Wheel Drive

Major Options: _______A/C; _________Pwr.Strg.; __________Pwr. Brakes

_______Pwr. Windows; _______Pwr. Door Locks; ______ Tilt Wheel

Date Received: ______________________; Odometer Reading _______________km

Dealer/leasee: ____

& Address: ____

DATA FROM VEHICLE'S CERTIFICATION LABEL:

Vehicle Manufactured by: ____

Date of Manufacture ____

GVWR: _______kg; GAWR: _________ kg FRONT; ____________ kg REAR

DATA FROM TIRE OR TIRE PLACARD:

Tire Pressure with Maximum Capacity Vehicle Load: _______________kpa FRONT

_______________ kpa REAR

Load Index & Speed Symbol: _____________________________

Recommended Tire Size: ________________________________

* Recommended Cold Tire Pressure: ___________________kpa FRONT; _______________kpa REAR

Tire Grades: ____________
Treadwear; ____________ Temperature; ______________ Traction

Size of Tires on Test Vehicle: ____________________; Manufacturer: __________________

Vehicle Capacity Data:

Type of Front Seats: ________________Bench; __________Bucket; ___________Split Bench

Number of Occupants: __________ Front; __________ Rear; 0 __________ Total

Vehicle Capacity Weight (VCW) = ____________________kg

No. of Occupants x 68 kg = ____________________kg

Rated Cargo/Luggage Weight (RCLW) = ____________________kg

*Tire pressure used for test

15. DATA SHEETS... Continued

DATA SHEET NO. 2 GENERAL TEST AND VEHICLE PARAMETER DATA (cont.)

WEIGHT OF TEST VEHICLE AS RECEIVED FROM DEALER (with maximum fluids) = UDW:

Right Front = ____________________kg Right Rear = _______________kg

Left Front = ____________________kg Left Rear = _______________kg

TOTAL FRONT = ____________________kg TOTAL REAR = _______________kg

TOTAL DELIVERED WEIGHT = _____________Kg

% of Total Front of Vehicle Weight = ________% of Total Rear Weight = _________%

WEIGHT OF TEST VEHICLE

Right Front = ____________________kg Right Rear = _______________kg

Left Front = ____________________kg Left Rear = _______________kg

TOTAL FRONT = ____________________kg TOTAL REAR = _______________kg

TOTAL TEST WEIGHT = _________Kg

% of Total Front Weight = ________% % of Total Rear Weight = ____________%

FUEL SYSTEM DATA :

Fuel System Capacity From Owner's Manual = _____________ liters

Usable Capacity Figure Furnished by COTR = _____________ liters

Test Volume Range (75 % to 100% of Usable Capacity) = __________ to _________ liters

ACTUAL TEST VOLUME= ____________ liters (with entire fuel system filled)

DATA SHEET NO. 3

PHOTOGRAPHS